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## MECHANICS.

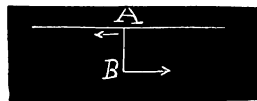
102. Proposed by WALTER H. DRANE, Graduate Student, Harvard University, Cambridge, Mass.

A heavy particle with a light string attached is placed on the edge of a smooth table. A boy, holding the string horizontally, runs at right angles to the string. Determine the motion of the particle (1) when the boy runs with a uniform velocity; (2) when he runs with a uniform acceleration.

Solution by the PROPOSER.

This problem is one of a class in which a clear idea of the motion may be gained without solving analytically.

Let  $A$  be the position of the particle at the start,  $B$  the position of the boy's hand. We shall suppose the boy runs to the right. Now the effect upon the motion of the particle will be the same if, instead of supposing the boy to run to the right, we impose upon space a hypothetical motion to the left, in such a way as to bring the boy's hand at  $B$  at rest. This of course necessitates imposing upon the particle at  $A$  the same motion that is imposed upon space.



In our first case thus we impose upon  $A$  a uniform velocity to the left. We have thus a particle acted upon by gravity, and moving about a fixed point with uniform velocity, *i. e.* a simple conical pendulum. So the result to (1) is that as the boy runs with uniform velocity the particle will move around his hand as a simple conical pendulum.

In our second case impose upon  $A$  a constant acceleration to the left. Our particle is thus acted on by two forces, constant in direction and magnitude, *viz.* gravity and this hypothetical horizontal force. It will therefore oscillate horizontally and vertically about  $B$ . Also since these two forces may be combined into a single oblique force constant in magnitude and direction, these two oscillations will be equivalent to a single simple oscillation obliquely about  $B$ . The result to (2) then, is that as the boy runs with uniform acceleration the particle instead of moving around his hand as a conical pendulum, will oscillate obliquely behind it.

103. Proposed by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Given the lengths  $a$ ,  $b$  of the sides of a parallelogram, the direction of side  $a$ , and the position of the centroid. Prove that the locus of the foci of the ellipse of gyration at the centroid is a Cassinian Oval, having its foci distant  $a/2\sqrt{3}$  from the centroid, and the constant product of its focal distances equal to  $\frac{1}{12}b^2$ .

Solution by the PROPOSER.

Let  $A$ ,  $B$  be the principal moments of inertia,  $m$  the mass of the parallelogram, then  $x^2/A + y^2/B = 1/m$  is the equation to the ellipse of gyration at the centroid.

$$\text{Eccentricity} = \sqrt{\frac{A-B}{A}}, \quad \text{semi-major axis} = \sqrt{\frac{A}{m}}.$$

$$\therefore \text{Distance of focus from center} = \sqrt{\frac{A-B}{m}}.$$

Let  $\theta$  = the angle the principal axes make with the sides. then if  $u, v$  be the coördinates of the focus, we easily get

$$u = \sqrt{\frac{A-B}{m}} \cos \theta, \quad v = \sqrt{\frac{A-B}{m}} \sin \theta.$$

$$\therefore u^2 + v^2 = \frac{A-B}{m}, \quad u^2 - v^2 = \frac{A-B}{m} \cos 2\theta.$$

From problem 94, solution on page 48, Vol. VII, No. 2, we get

$$u^2 + v^2 = \frac{1}{1^2} \sqrt{[a^4 + b^4 + 2a^2b^2 \cos 2\beta]}.$$

$$u^2 - v^2 = \frac{1}{1^2} (a^2 + b^2 \cos 2\beta).$$

Eliminating  $\cos 2\beta$  we get

$$144(u^2 + v^2)^2 = 24a^2(u^2 - v^2) - a^4 + b^4.$$

Let  $u = r \cos \varphi$ ,  $v = r \sin \varphi$ .

$$\therefore 144r^4 = 24a^2r^2 \cos 2\varphi - a^4 + b^4, \text{ or } r^4 = \frac{1}{6}a^2r^2 \cos 2\varphi - a^4/144 + b^4/144.$$

$$\text{If } a = b, \quad r^2 = \frac{1}{6}a^2 \cos 2\varphi.$$

104. Proposed by F. P. MATZ, M. Sc., Ph. D., Professor of Mathematics and Astronomy in Irving College, Mechanicsburg, Pa.

From a locomotive and tender standing still on a bridge, the pressure on the bridge is  $p_1 = 80$  tons. The track is supposed to be straight and practically horizontal. Had the locomotive and tender been running at the rate of  $r = 60$  miles an hour, how many tons would the pressure on the bridge have been?

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

$$p_1 = 80 \text{ tons} = W = mg.$$

Both  $m$  and  $g$  are constant.

$\therefore$  The pressure is the same, 80 tons, no matter what the velocity.

## — DIOPHANTINE ANALYSIS. —

83. Proposed by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Find three numbers in arithmetical progression whose sum is a square and cube.

I. Solution by J. W. YOUNG, Cornell University, Ithica, N. Y.; B. L. REMICK, Bradley Polytechnic Institute, Peoria, Ill.; and ALOIS F. KOVARIK, Decorah Institute, Decorah, Ia.

A number which is a square and a cube is a sixth-power.

Also three numbers in arithmetical progression may be represented by

$$a - d, \quad a, \quad a + d; \text{ whose sum is } 3a.$$